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Studies on Hevea Latex.

VI.—The Proteins in Serum from Frozen Latex.

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A continuation of the studies on Hevea latex with the object of investigating Belgrave's suggestion of the presence of a lipin complex (1) has led to the collection of some further data relating to the protein constituents of latex which it appears suitable to record at this stage.

In searching for a means to isolate a possible lipin-protein Belgrave demonstrated the possibilities to be derived from an examination of the serum of latex which had been coagulated by freezing. The present writer has investigated this method more extensively and thereby separated three protein bodies which it appears have hitherto not been described. Although the work of Arisz (2) on the nitrogenous constituents of latex from individual trees has indicated the probable presence of at least two different proteins.

Freezing latex as a means of coagulation has long been known but according to the literature available it has not been practised to any extent and the serum from frozen latex does not appear to have been investigated, although as long ago as 1911 E. Fickendey (3) recommended freezing as a means of obtaining the serum of Funtumia latex in the original state without the addition of a coagulant. Whitby (4) states that six to eight hours in a frozen condition will cause Hevea latex to coagulate but he offers no comment except to point out the significance of this with regard to the theory of coagulation. Eaton (5) found that latex formed a solid coagulum when frozen at a temperature of 15° to 20° F. for from four to eight hours, and he has published a long series of results on the tensile properties of vulcanised rubber prepared by freezing latex. It is not evident that the serum in those coagulations was entirely free from caoutchouc and the writer has found that in this respect there is an appreciable variation in the behaviour of latex from different sources even though conditions of acidity and dilution are maintained as uniform as possible

In the present investigations the most satisfactory coagulations have been obtained by freezing a perfectly fresh latex,

collected within two hours from first tapping and bottled before 10 a.m. Latex from recently opened cuts or from young trees and similar sources was found to behave abnormally, and the results to be recorded below refer only to normal latex of average composition.

Fresh latex with an acid value represented according to the conventionally adopted notation by pH $\tilde{c}$ 6.0-7.0 was strained into glass jars, 500 ccs each, which were evacuated and set in a cold chamber within four hours of tapping the tree. The temperature was maintained between 5° and 7°F. and the latex was removed when warmed samples showed that the serum was perfectly clear. Ten days cooling was required for the average preparation. The frozen latex was allowed to warm in the air at about 30°C the serum being removed from the coagulum as it thawed, by this means the liquid was filtered through its own coagulum and was obtained absolutely clear and water bright within six hours of its removal from the cold chamber thus avoiding decomposition by the development of bacteria. Imperfect freezing necessitated tedious filtrations through pressure filters and after some disappointing results it was considered advisable to reject any preparations other than those which thawed to a clear bright serum. The serum so prepared had a very pale yellow colour and the odour of freshly tapped latex. Its acid value was found to be the same as the original latex i.e. about pH 6.5. The clear serum had an optical rotation of the order $(a)_D^{30} = -20°$. Additions of dilute acids or alkalies gave precipitates; that which was obtained with dilute NaOH was nitrogenous and was soluble in excess of the reagent. The appearance of this precipitate is simultaneous with a distinct colour change in the solution at pH $\tilde{c}$ 7.7. The addition of half saturated ammonium sulphate solution or zinc sulphate gave precipitates. On heating to 60°-65°C or on standing at a temperature of 30°C it was found that the clear serum darkened and gave a precipitate which was nitrogenous.

By steam distillation of freshly frozen serum in the presence of one per cent. magnesia a small quantity of ammonia is evolved and the distillate has a pronounced aromatic odour.* It is not unlikely that the amido body from which this ammonia is derived is the same as that which occurs in the original latex and is not the result of products caused by the freezing. Perfectly fresh latex taken to the laboratory and tested within a few minutes of tapping the tree was found to yield ammonia on distilling with steam and magnesia; the amount varies from day to day but is of the order 0.005 grams N_2 per 100 ccs of latex containing 35 per cent. dry rubber. As it was not possible to extract the serum quantitatively from frozen latex it was not possible to mea-

*Ammonia in the serum of freshly coagulated latex was originally reported by K. Gorter. Arc. v. d. Rubberculture 1917 No. 11.

sure exactly whether any amido nitrogen had been formed during freezing but steam distillations with magnesia showed that the serum from frozen latex contained amido nitrogen of the same order as the original latex.

Protein A.—By acidifying the liquid with dilute acid a precipitate was thrown down which readily separated and could be filtered without difficulty. In practice it was found satisfactory to use a ten per cent. solution of acetic acid and acidify to a pH value of c. 4.5. The precipitate could be washed by dilute acetic acid and finally with water. In the preparations described here the acid precipitate was washed with acid and water and then suspended in water and dialysed in a vessel maintained at about 5°C. Dialysis was continued until the dialysate was no longer acid and gave negative tests for phosphate. This usually took 5 to 6 days. The precipitate was finally dried by alcohol and ether to a white granular powder which for convenience will be referred to henceforward as Protein A.

Protein B.—The filtered serum liquor with an acidity about pH 4.5 was saturated with sodium chloride crystals and allowed to stand. A precipitate slowly separated and after standing for 12 hours in an ice bath the supernatant liquor could be decanted. The precipitate was washed by repeated small quantities of ice cold saturated salt water.

The sodium chloride precipitate was soluble in water and was finally freed from salt by solution in water and dialysing the solution at about 5°C. This was carried out by the use of a double walled ice-cream freezer which was large enough to hold a two litre beaker containing six 100 cc dialysing thimbles and a litre of water. The latter was changed at frequent intervals. With freshly made collodion thimbles dialyses took five to six days. It was noticed that the dialysate invariably contained organic nitrogenous matter although the presence of bacteria was not indicated by the usual tests.* The dialysed liquid was evaporated at a low temperature and dried by alcohol and ether to a greyish powder which will be referred to subsequently as Protein B.

Protein C.—The sodium chloride saturated serum mother-liquor was heated on the steam-bath and a precipitate was thrown down. This was collected dried with alcohol and ether, ground and extracted with warm water until the washings were free from chloride and phosphate.

Residual Nitrogen.—The serum mother-liquor at pH4.5 after removal of the heat coaguable protein was found to give a well defined precipitate on the addition of sufficient 94 per cent. alcohol to bring the concentration of the liquor to approximately 70 per cent. alcohol. This precipitate was highly nitrogenous and contained an appreciable proportion of mineral matter but no attempt was made to ascertain

*Possibly due to proteose.

whether it could be resolved into simpler bodies. The mother liquor after filtration and concentration to its original volume was found to contain Kjeldahl nitrogen of the order 0.05 per cent.

Some information on the proportions in which these proteins occur can be gathered from the following figures which were the results obtained with one batch of latex collected from 18 year old trees. The fresh latex was gathered on the 17th of May and when brought to the laboratory had a pH c 6.9. Coagulation with acetic gave a coagulum 37 per cent. of the weight of the original latex, and the creped rubber had a Kjeldahl nitrogen content of 0.3 per cent. and an acetone extract of 2.6 per cent. Ten litres of latex were bottled in lots of 400 ccs and placed in a refrigerating chamber within two hours of the time when the latex was collected. Ten bottles of the frozen latex were removed from cold storage and thawed on the 1st of June and the remaining bottles were removed on the 20th of July. Treatment of the filtered serum was according to the procedure already described.

Nitrogen determinations etc., were made in duplicate and the figures recorded are the means of the two results.

	Fresh latex 17.5.16 parts per hundred	Frozen serum 1.6.26 parts per hundred	Frozen serum 20.7.26 parts per hundred
Specific gravity at 30° C.	0.975	1.012	1.012
Acidity p H. ...	6.8	6.8	6.8
N_2 by Kjeldahl ...	0.267	0.220	0.231
N_2 by distillation with Mg O ...	0.0064	0.0053	0.0051
N_2 by distillation with 1 per cent Na OH solution ...	0.0198	0.0137	0.0151
Total solids by evaporation at steam heat ...	41.50	5.03	5.06
Mineral matter by incineration ...	0.42	0.70	0.75
Solids coagulated by freezing ...	36.85	...	...
Solids coagulated by acetic acid ...	37.00	0.331	0.243
Solids in acetic acid serum coagulated by NaCl.	undetermined	0.100	0.131
Solids in NaCl serum coagulated by heat ...	0.15	0.14	0.14
Solids in the residual serum (after heating) coagulated by alcohol.	0.15	0.13	0.10
N_2 by Kjeldahl in the residual serum after heat and alcohol ...	undetermined	0.061	0.072

Repetition estimations on other samples of latex were carried out and the proportions of the various precipitates detailed above were found to vary with different batches of latex but the variations were small and not significant in view of the high experimental error involved. Throughout the series of preparations, which were carried out at approximately monthly intervals between January and December 1926, the serum obtained by freezing had an average specific gravity of 1.015 at 30°C and the total yield of the proteins A.B. and C. was 0.6 per cent. of the weight of the serum. The weight of protein A was always more than double the weight of either of the other two proteins.

It is not possible to attach any particular importance to the actual amounts recorded but the figures are of value as an indication of the proportions in which the proteins occur in Hevea latex and the comparatively small fraction of the total nitrogen of serum for which they account. In this connection it is of interest to recall that determinations of the insoluble fraction of plantation crepe recovered from solution in cymene showed that only 60 per cent. of the "Nitrogen calculated as protein" could be recovered (6).

Properties of the Proteins.—An examination of dilute alkaline solutions of the proteins prepared as above from ten different lots of latex collected between January 1926 and January 1927 gave the following results:—

—	*Protein A.*	*Protein B.*	*Protein C.*
Reaction of solution...	p H 9.0	p H 8.0	p H 10.0
Biuret Test ...	Positive	Positive	Positive
Adamkawicz Test ...	Positive	Positive	Positive
Molisch Test ...	Negative	Negative	Negative
Sulphur Test ...	Positive	Negative	Negative
Phosphorus Test ...	Positive	nil	nil
Addition of Alcohol	nil	nil	Precipitate
Heat ...	No coagulation	No coagulation	Coagulation at 65° C.
Ash per cent. ...	0. 5–0. 2	Trace	Trace
Nitrogen by Kjeldahl Extremes. Per cent.	14.0-15.1	15.4-14.5	16.9-16.4
Optical activity ...	Laevo	Laevo	Undetermined

Portions of the various preparations were bulked and hydrolysed with 25 per cent. hydrochloric acid. The nitrogen distribution in three groups was determined according to Van Slyke's method as elaborated by Plimmer and Rosedale (7).

The filtrates from the phospho-tungstate precipitates were freed from phosphotungstic acid by treatment with barium chloride and evaporated under reduced pressure before determining the mono amino nitrogen. In this evaporation no attempt was made to collect any ammonia which might have been evolved from unprecipitated arginine.

The following results were obtained:—

—	*Protein A*		*Protein B*		*Protein C*	
Amide N_2 ...	0.82	0.82	0.22	0.26	0.85	0.80
Humin N_2 ...	0.65	0.66	0.40	0.45	0.23	0.22
Diamino N_2 ...	3.24	3.30	8.00	8.10	1.67	1.60
Monamino N_2 ...	8.35	—	6.20	—	13.75	—
Total ...	14.06		14.82		16.50	

It has not been possible to study these proteins in any detail but some observations on Protein A may prove of interest.

It has been found that Protein A. in spite of attempts at purification by dialysis persists in showing the presence of phosphorus.

The amount is not constant but is always of the order 0.01 per cent.

If the purified protein is dissolved in dilute aqueous Na OH and then reprecipitated by dilute acid the phosphorus content can be reduced.

This has led to a series of investigations with the object of isolating the phospho bearing substance.

Freshly prepared Protein A was washed and dialysed in the usual manner until the dialysate showed complete absence of PO_4 when tested colorimetrically by the coeruleo—molybdate method (8). The protein was then disolved in water containing small additions of 1 per cent. aqueous Na OH.

The solution at pH $\bar{c}$ 9.0 was poured into a large volume of hot 95 per cent. spirit so that the final liquid contained about 70 per cent. alcohol. No precipitation occurred but on prolonged heating a small quantity of a granular precipitate was thrown down. This was filtered off but was not examined further. Upon the addition of 1 per cent. acetic acid to the filtered cold spirit solution of the protein a well defined precipitate was formed at pH $\bar{c}$ 6.5. This was allowed to

stand for 12 hours and then filtered and washed with 95 per cent. alcohol containing acetic acid. The clear filtrate was acidified further until the acidity was approximately pH 4.0 in order to ensure that no further precipitate was formed. It was then evaporated to dryness under a vacuum at a temperature of not higher than 50°C. The residue was a white very deliquescent solid and slightly acid to litmus, this probably being due to the presence of acetic acid. It was found however that if the alcohol filtrate after acidification to pH 4.0 was evaporated on the water bath the dry residue was distinctly alkaline to litmus.

The white deliquescent residue obtained by evaporation under reduced pressure was dried and taken up in alcohol-ether, in which it was almost completely soluble. The insoluable residue was discarded. The cold alcohol-ether solution was evaporated to a small bulk, made up with alcohol and again evaporated to ensure freedom from ether and then made up to the original volume. On the addition of four times the volume of cold acetone to the liquor a precipitate was obtained with a very characteristic appearance of waxy scales. This precipitate was filtered washed with acetone and dried in a vacuum dessicator. The acetone liquors on standing in the dark quickly developed a brown colour and on evaporation gave a small resinous residue.

Repeated preparations showed the dry material to be a white crystalline glistening substance very deliquescent and soluble in water to a solution of pH $\tilde{c}$ 8.0. The aqueous solution was found to be dextro-rotatory, the specific rotation being of the order (a) $^{20}_{D} = + 17.5$. On heating the substance charred but did not melt at a temperature of 250°C. By heating strongly in a closed tube amino vapours were evolved, followed by the odours associated with burnt sugars, and a bulky residue was obtained. The dry substance was found to be unaffected by exposure to light. It was soluble in dilute and strong caustic soda and dilute hydrochloric acid, insoluble in chloroform, benzene, petrol-ether, slightly soluble in ether and readily soluble in alcohol. The dilute soda solution gave a negative test for biuret.

The quantity of material available was insufficient to ascertain by quantitative analysis whether the above solvents effected any change in the composition of the substance though qualitative observations indicated that the substance was unaffected. Unconfirmed determinations of ash, nitrogen (by Kjeldahl), and phosphorous in the moisture—free material gave the following results:—

Ash	...	63.3 per cent.
Nitrogen	...	1.0 per cent.
Phosphate (PO_4)	...	0.07 per cent.

Conclusions.—The evidence indicates that the Protein A as described above is closely associated in latex with a non-protein substance or substances which are not dialyasable

in the ordinary way. Certain characteristics of this substance have been ascertained but whether it is a definite chemical compound remains to be proved, and also whether the whole of the phosphorous in the protein can be accounted for in this manner. It is possible that by electro-dialysis the protein could be completely freed from phosphorous (9) though it does not follow that the remainder of the associated substance would behave in the same manner as that already described. It seems however that the method of freezing latex has not enabled the separation of a protein associated with a lipin or similar body neither has it resulted in the isolation of any complex as originally conjectured. Further work in that direction will be recorded in the near future, together with some observations on the effects of these substances on the vulcanisation of plantation rubber.

In conclusion the writer wishes to record that the inception of this work was due to Mr. W. N. C. Belgrave to whom thanks are due for advice and constructive criticism, and also to record thanks to Inche Haji Wahid for assistance throughout the investigations. The writer is also very grateful to the Management of the Singapore Cold Storage Co. in Kuala Lumpur for permission to utilise their refrigerating chambers whenever required.

Summary.—The preparation from Hevea latex and separation of three protein bodies is described. These proteins have been characterised.

The purification of one of the proteins by dialysis is shown to leave the protein associated with a phosphorous and nitrogen containing substance or substances which can be extracted by alcohol. A description of the extract is given but the substance is not identified.

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Further Work on Treatment of "Wet-Root Rot."

A. Sharples.

The present article is a continuation of one published in the Malayan Agricultural Journal Vol. XIV.—No. 2, 1926. In view of the importance of this subject it seems advisable to reproduce much of what was written in the above-mentioned article.

The common root disease found on trees of *Hevea brasiliensis* over 10 years of age, commonly known as "Wet-Rot," the cause of which disease is the fungus *Fomes pseudoferreus* (Wake) has attracted much attention in recent years. Some observers regard this disease as one of the possible limiting factors in the longevity of rubber plantations in Malaya. The subterranean habit of the fungus gives but little indication of the number of affected trees in any particular area, and a typical infection is very impressive when the roots of affected groups of trees are opened up. The principal features with regard to previous work on this disease are as follows:—

Belgrave (1) was the first investigator who examined this disease in Malaya. Only imperfect fructifications were found growing under natural conditions so that the causal fungus could not be properly identified. The causal fungus was isolated from diseased roots, and fructifications were developed in the culture tubes. From these artificially developed fructifications along with the imperfect natural fructifications the fungus was named provisionally *Fomes pseudoferreus* by Miss Wakefield, of the Royal Botanic Gardens, Kew.

This disease is characterised by a typical "Wet-Rot" of the roots—the diseased tissue being spongy and wet, even in soils that might be considered dry. The diseased tissue seldom appears above ground level; in surface roots it is common to see the upper part, not in contact with the soil, free from attack, while the under part, in contact with the soil, is badly rotted. The disease becomes most conspicuous in old plantations and in some old properties a large percentage of trees can be found suffering from this disease.

A similar disease has been described from Java and the causal fungus is considered to be *Ganoderma ferreum* Berk. Recently (2) the authorities who gave this name to the causal fungus, have reconsidered the position and state that the fungus should now be known as *Ganoderma pseudo-ferreum* (Wakef) nov. comb. The question of systematic position is not of much importance for this article, but as the writer does not agree that a good case has been made out for change of name, the fungus will still be referred to as *Fomes pseudoferreus*. (Wakef).

In Malaya, the method of spread of the disease is by root-contact; as yet, only immature fructifications have been found in this country. Therefore, spread by dispersal of spores cannot be of much significance in Malaya.

The common method of preventing spread of root diseases is by digging trenches to isolate the diseased trees from the healthy trees. This method is apparently useless with reference to "Wet-Root Rot" and, to the writer, advice on the spot, after inspection, seemed the only satisfactory method of procedure. When a heavy infection has to be combatted, the only method to be recommended is the isolation of the infected group from the healthy portions of the estate by means of a continuous trench, without attempting to save individual trees by connecting trenches.

How many trees can be saved for the money spent is the question which must be considered, when advice in connection with combating root diseases is to be given. The general opinion has been, up to the present, that no positive evidence could be found to show the number of trees actually saved by treatment; the underlying idea has been that preventive measures are necessary to stop or retard the spread of the disease to healthy parts of the estate. The facts which are presented below are of such interest that a complete change of view may be necessary with regard to the consideration of treatment of this particular root disease.

The method of opening-up the diseased groups of trees was conducted as follows. A diseased group can be seen easily. All trees which showed obviously diseased roots were marked. Badly diseased trees, in which the fungus has passed from a diseased lateral root into the stem of the tree, were taken out immediatly. The neighbouring trees were next examined and all the roots followed out to their distal extremeties, twenty to thirty feet away from the trunk; if any of these trees were found with diseased roots, the opening-up was continued and the roots of the next tree were examined. This operation was carried on until healthy trees were found in all directions. This careful examination showed a large percentage of trees, the lateral roots of which were attacked at some distance from the trunk. Excision of such diseased roots behind the attacked portions prevented the fungus travelling towards the bole, thus saving a valuable tree. Further, careful digging to a depth of three feet showed that the disease was generally found on lateral roots growing in the upper nine inches of soil, so there was little danger of the fungus gaining an entry into the tap root at a lower level.

The figures covering 12 months' work are given in the table below. The table covers two periods from July 1925 to January 1926 and from April 1926 to October 1926. In the latter period no work was done in the months of July and August. The separation of these two periods is of interest to show that better results were obtained as further experience was gained.

Month.	No. of trees examined.	No. of trees Healthy.	No. treated by severance of lateral roots.	No. of badly diseased trees cut out.	Percentage No. of trees saved by treatment.	Total Cost.	Cost per tree.	Remarks.
July 1925	98	57	23	18	23.5 app.	No costs.	Nil.	
August ,,	209	139	41	29	20.0 ,,	$555.95	$2.18	
Sept. ,,	182	83	33	66	18.0 ,,	490.41	2.70	
October ,,	64	10	23	31	36.0 ,,	205.81	3.22	
Nov. ,,	175	84	45	46	26.0 ,,	533.51	3.05	
Dec. ,,	123	40	43	40	35.0 ,,	392.60	3.20	
Jan. 1926	137	55	45	37	33.0 ,,	428.48	3.12	Only two weeks working
Total ...	988	468	253	267	25.0 ,,			No work done February and March.
April 1926	92	22	44	26	49.0 ,,	281.70	3.06	
May ,,	82	31	38	13	46.0 ,,	209.05	2.55	
June ,,	94	39	27	28	29.0 ,,	214.96	2.28	
Sept ,,	34	9	17	8	50.0 ,,	41.55	1.22	Tamil labour
Oct. ,,	110	46	35	29	33.0 ,,	70.95	0.65	,, ,,
Total over whole period.	1400	615	414	371	30% ,,	$3424.97		

The figures show that over the first period 25 per cent. of the total number of trees opened up were saved by treatment; if we take only the diseased trees into consideration 253 out of 520 or approximately 50 per cent. were saved. During the second period 30 per cent. of the total number of trees were treated by severance of lateral roots while considering diseased trees only, 414 out of 785, approximately 53 per cent. The results are of the same order during the two periods, but the costs in September and October 1926 compare very favourably with all the previous monthly records. The total cost of treatment was $3,424.97.

Against this cost the claim is made that 414 fourteen year old trees were actually saved. Reckoned at 80 trees to the acre this represents a saving of five acres of good yielding mature rubber, and based on the prices common at the present date would be cheap at $1,000 per acre. So that there is an actual saving at the smallest estimate of $5,000, for an expenditure of $3,425. This must be considered sound finance, but a further claim is to be made. There is little doubt that if the 414 trees with slightly diseased laterals had been left standing without any attention, that many of the 615 trees opened up in close proximity but found healthy, would have become infected in a few years time and further large losses from the same cause would be recorded.

Experience gained in this work makes the task of spotting diseased trees more easy. The trees with diseased roots have one or two of the lower branches dead, the general foliage appears unhealthy and the leaves are usually small in size. An examination of the lateral roots at the foot of such trees should be made and particular attention should be paid to the colour of the bark. If the bark shows a slight reddish tinge the soil should be dug away to find if the underside of the root is diseased. If no obvious symptoms of disease are apparent on the undersurface, and the above symptoms are noted the root probably will be found infected further along the lateral away from the trunk. The root will need exposing to its distal extremity by coolies specially trained in the work. One diseased lateral was traced for a distance of forty five feet away from the stem; this diseased root infected roots of five other trees with which it came in contact at various places. Diseased laterals are seldom found more than one foot below the surface and they usually lie in the upper six inches of soil. Once the fungus travels into the tap root, it may travel downwards to the very tip; numbers of cases have been taken out showing eight feet of diseased tap root. A system of marking by differently coloured chalks aids in checking up the work, and any system can be devised.

The trees treated by the severance of the lateral roots fall into two classes.

(a) Trees which have been infected for a long time, so that the fungus has progressed along the lateral root until

the junction between stem and root is almost reached. The cutting of roots of large diameter will bring about similar results to those caused by severe root-pruning, and some detrimental effect on the general well-being of the tree might be expected.

(b) Trees with lateral roots which have been recently infected many feet away from the trunk, so that only roots of small diameter are cut. The (b) group contains many more trees than the (a) group and the cutting of a root of small diameter will not affect the tree to any great extent.

In the earlier article, the writer suggested that this particular disease would appear in "cycles" if further work confirmed the results obtained. Full confirmation has been obtained and the first cycle of disease can be expected some time after the tenth year. If no attention is paid to the trees with slightly infected roots, the second cycle will appear about the fifteenth year and this continuous reduction of the number of good-yielding old trees is bound to lead to a point when the area is no longer an economic unit. There is no doubt that many of the older properties in Malaya will suffer heavy losses in the future.

A question arises:—Are the old areas worth protecting in the manner indicated in the article or would it not be better to suggest modifications so as to cut down expenses, and trust to a replanting policy at an earlier date than would otherwise be the case?

Yields from several estates with certain areas of old trees varying from twenty three to thirty nine years of age have recently been collected by the Agriculturist (Rubber) in connection with an enquiry into the "Longevity of *Hevea brasiliensis*." I am indebted to this officer for the following figures which cover records over a period of twelve months.

Estate	A.	Yield per acre per annum	=	548	lbs.	Trees	39	years old
,,	B.	,, ,, ,,	=	508	,,	,,	31	,, ,,
,,	C.	,, ,, ,,	=	323	,,	,,	25	,, ,,
,,	D.	,, ,, ,,	=	598	,,	,,	29	,, ,,
,,	E.	,, ,, ,,	=	530	,,	,,	29	,, ,,
,,	F.	,, ,, ,,	=	587	,,	,,	25	,, ,,
,,	G.	,, ,, ,,	=	460	,,	,,	30	,, ,,
,,	H.	,, ,, ,,	=	408	,,	,,	29	,, ,,
,,	I.	,, ,, ,,	=	500	,,	,,	23	,, ,,

When it is remembered that these areas have passed through all the vicissitudes which cannot be gauged when a new industry makes a successful start followed by rapid expansion; when knowledge of cultivation and manufacture has to be gained by rule-of-thumb methods; when boom periods are passed through with the consequent endeavour to obtain all immediate profits, whatever the risks, it is a tribute to the

vitality of *Hevea brasiliensis* to be able to show records of 548 lbs. per acre per annum at 39 years of age. There is little doubt that better records would have been obtained had the trees had the care which up-to-date knowledge suggests. In the writer's opinion the yield figures from old areas, presented above, is a very strong argument in favour of carrying on the treatment for the control of Wet-Root Rot, as indicated in this article.

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A Preliminary Report on Tapioca Varieties grown at the Government Plantation, Serdang.

J. Lambourne.

The Tapioca or Cassava plant (Manihot utilitissima) is cultivated for its tubers, from which the starchy material is extracted to make the various forms of tapioca or cassava and starch of commerce. The tubers of some varieties can be eaten raw, or cooked in a similar manner to the potato. As a vegetable, or as tapioca, it is valuable as an addition to the food supply of any country and its cultivation should therefore be encouraged. In addition to the uses described above, it is largely grown by Chinese as a food for pigs; further, the tubers are also a potential source of power alcohol.

With a view to obtaining improved and heavy yielding varieties, cuttings of reported good yielders were introduced by the Department of Agriculture F.M.S. & S.S. from the Philippine Islands and Java. These, together with three local varieties, have been cultivated here for several years and it is now thought advisable to place on record the results of trials so far conducted and, as far as possible, to indicate which varieties are the most promising as regards yields.

Varieties Under Trial.

The varieties experimented with and the sources from which they were obtained are as follows:—

The varieties from the Philippine Islands were received from the College of Agriculture, Los Banos and those from Java from the Director of Agriculture, Buitenzorg.

Plantation No.	Name under which Introduced.	Source.
Native No. 1 ...	Local white ...	Locally, Chinese garden
„ No. 2 ...	Green Native ...	„ „ „
„ No. 3 ...	Johore variety ...	Johore
Philippine No. 1	Casjane Singkong Manis † ...	Philippine Islands
„ No. 2	Mandioca Sao Pedro Preto ‡ ...	„ „
„ No. 3	Aipin Mangi * ...	„ „
„ No. 4	Mandioca Basiorao § ...	„ „
„ No. 5	Kapo White or Green ...	„ „
Java No. 6 ...	Aipin Valanca ...	Java
„ No. 7 ...	Aipin Mangi ...	„
„ No. 8 ...	Mandioca Basiorao ...	„
„ No. 9 ...	„ Criolinha § ...	„
„ No. 10 ...	„ Sao Pedro Preto § ...	„

‡ See page 57.
† This not the same as the Java A Mangi.
* This is the same as the Java A Mangi.
§ These varieties are poisonous.

It will be seen that three of the varieties from Java bear the same names as three of those from the Philippine Islands. I am informed by the Director, General Experiment Station, Department of Agriculture; Industry and Commerce, Buitenzorg, Java that the varieties which we obtained from there originally came from Brazil and were introduced before 1911, the exact date being unknown. All of these varieties were sent to the Philippine Islands and in a paper "Variety Tests of Cassava Based on Production" by Pedro L. Sison, Experiment Station, Contribution No. 62 of the College of Agriculture, Los Banos (1921), it is acknowledge that these varieties with one exception came from Java. Kapo White or Green is from Mindanao.

Before describing the varieties and dealing with tests carried out at Serdang a few notes on the yields and usefulness of the various varieties, extracted from the paper by P. L. Sison quoted above, will be of interest and will serve as a comparison with the results obtained here.

Of the five varieties received from the Philippines, Mandioca Sao Pedro Preto was the only one that was found to be unpalatable when cooked. This variety is bitter (poisonous uncooked) and cannot be eaten raw, or cooked; it is however a very fine variety for the manufacture of tapioca starch and flour and is a high yielder.

In palatability the varieties Kapo Green, Mandioca Basioroa and Aipin Mangi are said to be the best. They are of good flavour fine texture and nearly free from fibre.

The best varieties in respect of fineness of texture and sweetness are Kapo Green, Mandioca Basiorao, Aipin Valenca and Aipin Mangi. These varieties are also the best for boiling and consumption as a vegetable, they were also found to be good yielders.

The best varieties for commercial manufacture of starch and flour are said to be Aipin Valenca, Mandioca Basiorao and Mandioca Sao Pedro Preto.

Yields obtained from these varieties in the Philippines are as follows:—The yields are calculated per plant and they were taken when the plants were one year old.

TABLE I

Name of Variety		Average Yield per Plant from less than 20 plants of each.	
		Kilogramme	lbs.
Kapo White or Green	...	2.91	6.04
Aipin Valenca	...	3.07	7.05
Casjane Singkong Manis	...	2.16	4.75
Mandioca Sao Pedro Preto	...	1.80	3.96
Aipin Mangi	...	1.21	2.66
Mandioca Basiorao	...	3.40	7.48

The following figures are from another trial and are based on the average of 100 plants at the age of 12 months:—

TABLE II.

Name of variety	Average yield per plant.	
	Kilogrammes	lbs.
Kapo White or Green ...	1.522	3.35
Casjane Singkong Manis ...	1.614	2.55
Aipin Valenca ...	2.097	4.61
Aipin Mangi ...	3.570	7.85
Mandioca Basiorao ...	3.820	8.40
„ Sao Pedro Preto ...	3.850	8.62

All the varieties appear to be ready for harvesting at 11 to 12 months from date of planting.

In pamphlet No. 48 of the General Agricultural Experiment Station, Java, M. van der Meer describes experiments conducted to ascertain the cost of cultivation of Tapioca and gives the yields obtained from different varieties. As this report is dealing only with yields no costing figures have been extracted. The figures are of interest, however, to compare with the yields obtained at Serdang from the same varieties. Before giving any details of yields the methods of cultivation used by M. Van der Meer, are discribed below:—

The area used for the experiments was 5.11 hectares (=12.98 acres) of non-irrigated Sawah fields in the Seed Garden at Moeara. The soil was moderately heavy laterite and previous to planting tapioca a crop of Yellow Menada Maize with *Crotalaria anagyroides* inter-planted as green manure was grown on 4.26 hectares (=10.82 acres). After harvesting the Maize crop the Crotalaria was allowed to grow for another two months when it was ploughed into the ground. At that time the Crotalaria was 4½ to 5 months old and was just beginning to flower. On the balance of the area "Katjang tanah" (Groundnuts) had been grown, the foliage of which had been fed to cattle after harvesting the seed crop.

Soil Tillage.—In those plots where draught cattle could be used the green manure was rolled down with an iron roller and afterwards ploughed under about 8″ deep. The harrowing was done with a disc harrow. In the smaller plots the Crotalaria plants were pulled out and, while still green, changkolled under.

The planting distance was 3ft. x 4ft. and the cuttings used were from plants 12 months old.

Weeding was carried out five times; once with changkolls, once in both directions with the Moeara weeding implement and three times by women, the weeds being removed from the field on each occasion.

The crop was harvested after 12 months growth and the following table shows the area and yield of the tubers from each of the five varieties being grown at Serdang. The yields from other varieites used in this experiment have been omitted as they have no bearing on this report:—

TABLE III.

Variety	Area in Hectares	Area in acres	Total Yield in Kilogrammes of unscraped tubers	Yield in Kilogrammes of unscraped tubers per hectare.	Yield tubers per acre, lbs.	Unscraped Tubers per acre, piculs
Mandioca S.P. Preto...	1.6797	4.27	71,333	42,461	36,775	275.82
M. Criolinha ..	.6373	1.62	21,667	33,991	29,440	220.81
Aipin Valenca ...	.4826	1.23	12,355	25.601	22,174	116.30
,, Mangi ..	.3442	.87	10,292	29,900	25,900	194.25
M. Basiorao ...	.4503	1.14	12,365	27,459	23,783	178.35

The following further set of figures is extracted from pamphlet No. 49 of the General Experiment Station, Buitenzorg. The pamphlet is written by L. Koch and M. van der Meer.

The figures are taken from the results of a selective thinning experiment which was carried out in the Seed Garden at Moeara. The object being to ascertain whether there would be any advantage in planting single cuttings 3ft. x 4ft. or planting 1ft. x 3ft. + 1, i.e., in either single or double rows, and thinning out to the same number of plants per acre as there are in the single 3ft. x 4ft. plots, allowing the strongest plants to remain. It was found that there was a slight advantage to be derived from selective thinning out but the difference was not very big. However the figures extracted are not taken with a view to the advantages or otherwise attached to a system of thinning out, but to show the relative yields obtained from the different varieties used in the experiment, for the purpose of comparison with yields obtained at Serdang.

The following table gives the yield per plant obtained in the above experiments. The figures represent averages from a large number of plants:—

TABLE IV.

Name of Variety.	No. of Plants from which average taken.	No. of Plots.	Yield per plant		Average lbs. per acre.
			Kilos.	lbs.	
Mandioca Criolinha	600	20	4.31	9.48	31,027
„ Basiorao	1908	6	3.76	8.28	27,531
Aipin Mangi ...	2868	10	3.13	6.88	22,898
Mandioca Sao Pedro Preto ...	6564	24	5.23	11.49	38,203
Aipin Valenca ...	976	4	2.79	5.78	20,577

It will be noted that in both these tables Mandioca Sao Pedro Preto is the best yielder, with Mandioca Criolinha a good second, while Aipin Valenca is the poorest yielder in both cases. These results coincide with results obtained in the Philippines (see Table II)).

REPORT ON TRIALS CARRIED OUT AT THE GOVT. PLANTATION SERDANG.

For convenience this report will be divided into the following parts:—

(*a*) Yields from Philippine varieties in the Nursery.

(*b*) Yield trials with Philippine and Native varieties.

(*c*) Yields from Philippine varieties when used as a Catch-crop among African Oil Palms.

(*d*) Yields from Java varieties in trial with Native varieties.

(*e*) Yields from Java varieties in the Nursery.

(a) *Yields from Philippine Varieties in the Nursery:*—

In March, 1923 six small cuttings each of five varieties of Tapioca were received from the College of Agriculture, Los Banos, Philippine Islands. These were planted in nursery beds and were harvested in March, 1924. The growth of these plants was vigorous and the yields from six plants of each variety were as follows:—

TABLE V.

Plantation No.	Name.	Total yields lbs.	Average weight tubers per plant lbs.
Philippine No. 1	Casjane Singkong Manis	88	14
,, ,, 2	Mandioca sao Pedro Preto	235	39
,, ,, 3	Aipin Mangi	56	9
,, ,, 4	Mandioca Basiorao	277	38
,, ,, 5	Kapo green or white	101	17

There are large differences in yields between the different varieties and the figures indicate that Numbers 2 and 4 are exceptionally heavy yielders. Owing to the small number of plants, however, very little significance can be attached to these abnormal figures, although they correspond closely with the figures given in Table II as regards relative productivity.

Cuttings from the above plants were again planted in the nursery and there was sufficient material to plant one-tenth of an acre of each variety. These plots were planted on 17th March, 1924 and about 95 per cent. of the cuttings were established. The distance of planting was 3 ft. x 3 ft. square, giving 4,840 cuttings to the acre. The soil is a sandy loam and a crop of groundnuts had been harvested from these plots just previous to planting the tapioca cuttings.

The following table contains data collected during the growth of these tapioca varieties and also the yield at harvest. The date of harvest was February, 1925.

TABLE VI.

Details of observations	No.1	No 2	No 3	No 4	No 5
Date of planting -	17- 3-24	17- 3-24	17- 3-24	17- 3-24	17- 3-24
Date first flower noticed -	14-11-24	9-10-24	13-10-24	11-10-24	23-10-24
Average flowering age days -	278	258	266	265	262
Average height -	11′ 6″	7′ 6″	9′ 2″	8′ 8″	11′ 2″
Average weight tubers per plant -	2.31	4.73	1.58	3.20	1.99
Average yield per acre lbs. -	11,200	22,848	6,608	14,560	9,632

The figures for yields given in the above table coincide with those in Table V, in that Numbers 2 and 4 are much better yielders than the rest and Number 3 has continued to yield very poorly.

(b) *Yield Trials with Philippine and Native varieties.*—

These trials were carried out on Block 30, Plot F, with a view to comparing the yielding capacity of the five varieties from the Philippines with those usually grown locally. The local varieties used in this trial are all commonly grown and are known on this plantation as Native Numbers 1, 2 and 3.

The area under these trials was approximately one acre, being 219 feet East and West and 199 feet North and South. The trial consisted of 64 rows 219 feet long, and three feet apart, running East and West of the Block, with one guard row at each end. Each row represented a plot one sixty-sixth of an acre in area containing 73 plants. Eight plots of each variety were planted and arranged as shown in Table VII.

All the plots were planted between 18th February, 1925 and 19th February, 1925 in the usual way, that is, the cuttings were planted three feet apart and careful supervision was given to see that the varieties were not mixed.

TABLE VII.

Order of Plots from South to North.

*1	Native	No. 1	23	Native	No. 1	45	Native	No. 3
2	,,	,, 1	24	Philippine	,, 1	46	Philippine	,, 4
3	Philippine	,, 1	25	Native	,, 2	47	,,	,, 5
4	Native	,, 2	26	Philippine	,, 2	48	,,	,, 4
5	Philippine	,, 2	27	,,	,, 3	49	,,	,, 5
6	,,	,, 3	28	Native	,, 3	50	Native	,, 1
7	Native	,, 3	29	,,	,, 3	51	Philippine	,, 1
8	Philippine	,, 4	30	Philippine	,, 4	52	Native	,, 2
9	,,	,, 5	31	,,	,, 5	53	Philippine	,, 2
10	Native	,, 1	32	Native	,, 1	54	,,	,, 3
11	Philippine	,, 1	33	Philippine	,, 1	55	Native	,, 3
12	Native N	,, 2	34	Native	,, 2	56	Philippine	,, 4
13	Philippine	,, 2	35	Philippine	,, 2	57	,,	,, 5
14	,,	,, 3	36	,,	,, 3	58	Native	,, 1
15	Native	,, 1	37	Native	,, 3	59	Philippine	,, 1
16	Philippine	,, 1	38	Philippine	,, 4	60	Native	,, 2
17	Native	,, 2	39	,,	,, 5	61	Philippine	,, 2
18	Philippine	,, 2	40	Native	,, 1	62	,,	,, 3
19	,,	,, 3	41	Philippine	,, 1	63	Native	,, 33
20	Native	,, 3	42	Native	,, 2	64	Philippine	,, 4
21	Philippine	,, 4	43	Philippine	,, 2	65	,,	,, 5
22	,,	,, 5	44	,,	,, 3	*66	Native	,, 1

*Guard plots.

Harvesting took place during May, 1926, fifteen months from planting, and was carried out as follows:—Each plot was taken up separately and the tubers weighed, the number

of plants per plot was also counted. The figures for yields in the following table are the average from eight plots of each variety.

TABLE VIII.

Plantation No.	No. of Plots.	Average Yield tubers per plot lbs.	No. of plants per plot.	Yield tubers per plant lbs.	Calculated Yields per acre.	
					lbs.	piculs.
Native No. 1	8	288	59	4.85	19,008	42.56
,, 2 -	8	189	47	4.01	12,474	93.55
,, 3 -	8	208	49	4.20	13,728	102.96
Philippine 1 -	8	352	63	5.19	23,892	179.19
,, 2 -	8	209	48	4.38	13,794	103.45
,, 3 -	8	191	56	3.47	12,606	94.55
,, 4 -	8	332	63	5.42	21,912	164.34
,, 5 -	8	251	59	4.06	16,566	126.99

As the figures in column four Table VIII show, there was a large number of vacancies in all plots, some having almost fifty per cent. This was partly due to cuttings not taking root and to disturbance by weeders when the cuttings were beginning to grow, but a certain number can be accounted for by theft. It is well known that Tamils and also Chinese Coolies are fond of tapioca tubers, especially when they are young. The above figures are, therefore, on the poor side as regards yield, and as a comparison of yields between the different varieties, they are not too reliable. However, by using the yield per plant as a basis for calculation a fair comparison can be obtained. The number of vacancies, resulting in more room to each plant, have not increased the yield per plant, in fact the yield per plant appears to be smaller in the plots where most vacancies occurred. Of course, it is very difficult to say whether this would have been the case had there been no theft, for one or even two tubers may have been taken from a plant and it would still grow and be counted at harvest. The figures coincide nearly with those obtained in the nursery, Philippine Nos. 1 and 2, however, appear to have changed places as regards yield, but Philippine No. 3 continues to be the poorest yielder. It will be seen that the local varieties, especially Native No. 1, which is the one very commonly grown in Chinese gardens compares favourably with those from the Philippines. Philippine No. 4 still appears to be a good yielder when compared with the other varieties.

(c) *Yields from Philippine Varieties of Tapioca when grown as a Catch crop among Oil Palms.*

The area selected for this experiment was a strip of ten rows of Oil palms in Block No. 21. This strip was divided into five one-acre plots, each acre plot being planted with a different variety of tapioca. The land previous to planting the Oil palms had been cleared of blukar and lallang, after which it was ploughed, and disc-harrowed several times. The palms are planted 28 ft. x 28 ft. triangular; the rows running East and West being approximately 24 ft. apart, (i.e., the vertical height of the triangle). The tapioca cuttings were planted in five rows 3 ft. x 3 ft. on the middle twelve feet between the rows of palms, leaving six feet on either side for the development of the young palms. The area under tapioca in each acre plot was 0.604 or approximately 3/5 acre. The palms were only about 2 feet high when the tapioca cuttings were planted.

The varieties of tapioca used were the same as those named above and the cuttings were obtained from the one-tenth acre plots in the nursery.

Harvesting and Yield.—The crop was harvested during June, 1926 and for the purpose of calculating yields, the area under each variety was divided into nine plots of 0.067 acre each, that is, the area actually planted with tapioca between every two rows of palms. If all the cuttings that were planted had grown into plants there would have been 65 plants per row or 325 between every two rows of palms, making 2,925 in the acre plot. There were, however, a number of vacancies, and the actual number of plants to reach maturity was in some cases considerably less than this.

The actual yields obtained from each acre plot are given in Table X below. The yield per acre is calculated on an area of 3/5 acre actually planted in each acre plot of Oil palms.

TABLE IX.

Weight of Tubers per Plant together with the number of plants harvested and the percentage vacancies.

Plantation No.	Total Yield of tubers from each plot in lbs.	No. of Plants harvested	Average weight of tubers per plant. lbs.	Percentage vacancies	Comparison of yields The mean 10.893=100
Philippine 1 ...	10,835	2,024	5.4	30.8	99.5
„ 2 ...	12,425	1,556	8.0	46.8	114.1
„ 3 ...	6,123	1,927	3.2	34.1	56.2
„ 4 ...	15,237	2,296	11.8	21.5	139.9
„ 5 ...	29,843	2,230	4.4	23.8	90.4

TABLE X.

Yields from each acre plot and also yields per acre calculated on 3/5 acre planted in each plot.

Plantation No.	Total yield tubers from each plot, lbs.	Total yield tubers from each plot, piculs	alculated yield per acre, lbs.	alculated yield per acre, piculs
Philippine 1 ...	10,835	21.01	18,058	135.44
„ 2 ...	12,425	93.19	20,708	155.31
„ 3 ...	6,123	45.92	10,205	76.79
„ 4 ...	15,237	114.25	25,395	190.46
„ 5 ...	9,843	73.82	16,405	123.01

Here again the number of vacancies is large and in this case also there appears to be no correlation between the number of vacancies and weight of roots per plant. The figures for yields coincide with those obtained in the nursery, that is, Nos. 2 and 4 appear to be much heavier yielders than the rest, and No. 3 still very poor.

(d) *Yields from Java Varieties in trial with Native Varieties.*—

In November, 1924 two cuttings of each of the Java varieties of tapioca mentioned on page (7) were received from the Director of Agriculture, Buitenzorg, Java. These were planted in nursery beds and grown on until 17th April, 1925 when they were cut back to provide planting material for a trial with local varieties. It will be noticed that three of these varieties have the same names as three of those from the Philippine Islands, namely Apin Mangi, Mandioca Basiorao and Mandioca Sao Pedro Preto. The area used for this trial was the North East corner of Block No. 30, Plot J. The general arrangement of plots was similar to that used in the Philippine variety trials, but owing to the small amount of planting material available only a few cuttings of each variety could be planted in each plot. These were in all cases planted on the Eastern end of the plots, the remainder of each plot being filled with a local variety.

All the plots were planted on the 18th April, 1925, the cuttings used being 9 inches long and from mature parts of the stem. The planting distance was 3 ft. x 3 ft., each plot being a row 219 feet by 3 feet and there were 64 plots with one guard plot at one end and two at the other making 66 plots to the acre. The following table shows the order of planting: —

TABLE XI.

Order of Planting.

Plot No.	Java No.	Plants No. of	Native No. 1	Native No. 3	Plot No.	Java No.	No. of Plants	Native No. 1	Native No. 3
*1			73		34	9	16		57
2	6	7		66	35	10	10		63
3	7	8	65		36			73	
4				73	37	6	7		66
5	8	17	56		38	7		65	
6	9	16		57	39				73
7	10	11		62	40	8	17	56	
8			73		41	9	15		58
9	6	7		66	42	10	10		63
10	7	8	65		43			73	
11				73	44	6	7		66
12	8	17	56		45	7	8	65	
13	9	16		57	46				73
14	10	11		62	47	8	16	57	
15			73		48	9	15		58
16	6	7		66	49	10	10		63
17	7	8	65		50			73	
18				73	51	6			67
19	8	17	56		52	7	8	65	
20	9	16		57	53				73
21	10	11		62	54	8	16	57	58
22			73		55	9	15		
23	6	7		66	56	10	10		63
24	7	8	65		57			73	
25				73	58	6	6		67
26	8	17	59		59	7	7	66	
27	9	16		57	60				73
28	10	11		63	61	8	16	57	
29			73		62	9	15		58
30	6	7		66	63	10	10		63
31	7	6	65		64			73	
32				73	*65			73	
33	8	17	56		*66			73	

*Guard rows.

Harvesting took place in July, 1926 when the plants were 15 months old. The method of harvesting was similar to that used in the case of the Philippine varieties, each row or part of a row being harvested and weighed separately. The number of plants was also counted to provide data for the calculation of yield per plant. A summary of these calculations will be found in Table XII below:—

TABLE XII.

Plantation No.	No. of Plots.	Weight of tubers, lbs.	No. of Plants Harvested.	Weight of tubers per Plant, lbs.
Native No. 1	30	3,833½	1,257	3.13
„ „ 3	36	7,382½	1,643	4.49
Java „ 6	9	304½	41	7.42
„ „ 7	9	337½	49	6.89
„ „ 8	9	1,146¼	76	15.09
„ „ 9	9	577½	56	10.30
„ „ 10	9	214½	32	6.70

(e) *Yields from Java Varieties in the Nursery.*—

As stated above, two cuttings of each of five varieties were received from Java on 19th November, 1924. Each of these were divided into two and were planted in a small bed in the nursery. They all grew well and on 17th April, 1925 were cut back to provide planting material for the trials described above. The tubers were lifted on 28th July, 1925 before they were mature, as they were required for an exhibit at the Agri-Horticultural Show in Kuala Lumpur. The following data were collected at the time they were harvested: —

TABLE XIII.

—	No. 6	No. 7	No. 8	No. 9	No. 10
No. of Tubers -	77	98	78	73	57
Weight of Tubers lbs. -	61	74	49	72	70
„ „ per plant lbs. -	15.25	18.50	12.25	18.00	17.50

The cuttings from this stock were planted in the nursery; one-twentieth of an acre plot of each variety being planted on 27th March, 1925. With the exception of No. 8 there were enough cuttings to plant 11 rows of each variety with 22 cuttings in each row, the same number of rows were planted with No. 8, but there were vacancies left owing to there not being enough cuttings of this particular variety.

The soil on which these Tapioca varieties were planted was similar to that on which they were grown previously, a little cattle manure being applied before planting.

These plots were harvested on the 5th November, 1927, approximately 16 months from date of planting and the following table (XIV) shows the yields obtained:

TABLE XIV.

Yields from one-twentieth acre plots in Nursery.

Plantation No.	Yield per plot, lbs.	Calculated yield per acre, lbs.	Calculated yield per acre, piculs.	No of plants harvested.	Yield per plot, lbs.
Java No 6	1,260	25,200	189.60	205	6.15
7	1,600	32,000	240.00	201	7.96
8	2,315	46,300	347.25	215	10.77
9	870	17,400	130.50	118	7.37
10	955	19,100	143.25	125	7.64

As the above yields are from a single plot of each variety the above yields are from a single plot of each variety much reliance should not be placed on the figures, but by summarising the results obtained from different plantings it may be possible to get some idea as to the best yielders. It might be mentioned that this is only a preliminary report and that all these varieties are still under trial under conditions calculated to give fairly accurate results, and it is hoped that something more definite may be said concerning the merits of the different varieties when compared with each other on the completion of these trials.

The following relative values have been worked out from a summary of the yields per plant obtained from the tables above, Native No. 1 being taken as 100.

	Java Varitieties.	Philippine varieties.	Native varieties.
J No. 8. M. Barirao -	291.0	—	—
„ „ 9. M. Criolinha -	283.0	—	—
„ 10. M. Sao Pedro Preto	271.4	P2. 149.1	—
„ 7. Aipin Mangi -	252.1	P4. 182.0	—
„ 6. „ Valenca -	193.2	—	
N 3. Native No 3 -	—	—	109.0
P 1. Casjane Singkong Manis -	—	P1. 101.3	—
N 2 Native No 2 -	—	—	100.5
N 1 Native No 1 -	—	—	100.0
P 5 Kapo -	—	P5. 99.5	—
P 3 -	—	P3. 93.5	—

Conclusions.

A perusal of the tables will show that each of the two varieties Mandioca Sao Pedro Preto and Aipin Mangi have given the best yields four times out of ten, whilst on the other two occasions M. Basiorao gave the best yield, M. Criolinha has also yielded well and has taken second place four times and A. Mangi three times out of ten. The other three to take second place were M. Sao Pedro Preto, A. Valenca, and Casjane Singkong Manis. The last but one is not so good, however, when compared with those mentioned above.

The yields obtained at Serdang compare favourably with those obtained in the Philippines, and the yields obtained, under nursery conditions in the case of Java varieties, also compare favourably with yields obtained in Java. Wherever these introduced varieties have been planted on a large scale they have not been so good, due, no doubt, to the poverty of the soil on this plantation.

The native varieties yield about 100 piculs per acre for the first crop while with some of the Philippine varieties 190 piculs was the highest yield obtained and this was with Philippine No. 4 (A Mangi) when grown among the Oil palms. The next highest yield was 179 piculs with P. No. 1. (Casjane Singkong Manis) and 164 piculs P. No. 4. (A Mangi) in trial with native varieties, whilst in these trials Native No. 1. gave 142½ piculs per acre. The latter results were calculated from 8 plots of each variety 1/66 acre in area.

It might be stated that the yields usually obtained in this country on good land are in the region of 175 to 200 piculs per acre for the first few crops.

Descriptions of Tapioca varieties grown at the Government Plantation, Serdang.

Native No. 1. Local White.

Tubers.—Outer skin (corky layer) white, inner skin (cortex) tinged pink, flesh white.

Stem.—Outer skin (corky layer) silvery grey on mature stems, inner skin (cortex) light green. Young part of stem light green with red longitudinal stripes on ridges, nodes red.

Leaves.—Leafstalks (petioles) light red, out-growth at base of leafstalks (stipules) red at base both inside and out. Leaflets usually 7, dark green and shining above, paler green and dull below. Midrib of leaflets tinged pink on both surfaces. Young leaves purplish green. Young leafstalks bare.

The above descriptions agree also with that given for the variety grown in Java under the name of Red Singapore.

NATIVE No. 2. GREEN NATIVE.

Tubers.—Corky layer white, cortex cream coloured, flesh white.

Stems.—Corky layer light silvery grey lighter in colour than native No. 1, cortex dark green. Young parts of stem dark green with dark purple markings at nodes and on ridges near tip.

Leaves.—Petioles dark purple at base and light green, tinged red, towards leaflets. Stipules dark purple at base both inside and out, leaflets dark green above, light green beneath.

Midribs of leaflets green on both surfaces. Young leaves purple; young leaf petioles green and bare.

This variety is very like the Purple Preanger of Java, it differs, however, in the nerves of the leaflets being green on both surfaces instead of conspicuously red at the bases on the outer side, as in Purple Preanger.

NATIVE No. 3.

This variety appears to be the same as Philippine No. 1.

PHILIPPINE No. 1.

Tubers.—Corky layer white, cortex creamy white, flesh pure white.

Stems.—Erect very few branches, corky layer light grey to silver, cortex light green, young stems light green with red strips on ridges. Leaf bases remain red on stem until it is mature.

Leaves.—Petioles light red. Stipules red at base both inside and out, leaflets usually 7 dark green above light green beneath. Midribs of leaflets tinged red on both surfaces. Young leaves purplish in colour, young leafstalks bare.

This variety has been grown here under the name of Casjane Singkong Manis, but a description of this variety recently received from the Director of Agriculture. Philippine Islands does not agree with the above. I think that the variety in the Philippines from which the description was taken is wrongly named, for the variety grown in Java under the name of Aipin Valenca is the same as Casjane Singkong Manis of the Philippines, and different from the variety grown here under the latter name.

Our Philippine No. 1, to all outward appearances, is the same as Native No. 3 and differs from Native No. 1 in the cortex of the tubers being creamy white in the former two and tinged pinked in the latter. The habit of growth differs also in that Native No. 1 branches and flowers much earlier and more freely than either of the other two.

PHILIPPINE No. 2. MANDIOCA SAO PEDRO PRETO.

This variety is said to be poisonous.

Tubers.—Corky layer yellow-brown to deep brown, cortex white, flesh white, Tubers sessile on base of stem and conical in shape.

Stems.—Short, branching, corky layer on mature stems chocolate to purplish brown. Cortex dark green, young stems dark green with purple blotches.

Leaves.—Petioles deep claret colour above, and light green and red below, stipules red at base on inside, leaflets dark-green above light beneath. Midribs of leaflets reddish above and green beneath, young leaves have a light brown tinge. Young leafstalks hairy. Leaves near tips of branches at time of flowering trilobate.

PHILIPPINE No. 3.

Tubers.—Corky layer white, cortex white, flesh white, tubers long and thin.

Stems.—Corky layer grey, cortex light green, young stems green with red strips on ridges. The bases of petioles remain red on stem until it matures.

Leaves.—Petioles light red, stipules reddish purple at base both inside and out. Leaflets large, 7—9 in number, dark green above, whitish green beneath. Midrib of leaflets pink on both surfaces. Young leaves purplish, young leafstalks bare.

This variety came from the Philippines under the name of Aipin Mangi but it is not the same as the Java variety of that name. The foliage and stems are very like Philippine No. 1 but differs in having long thin, whip-like tubers.

PHILIPPINE No. 4. AIPIN MANGI.

Tubers.—Corky layer yellow-brown to deep-brown, cortex pink, flesh white.

Stems.—Corky layer brown with dark spots, cortex dark-green young stems green. The stems grow almost erect and do not branch early.

Leaves.—Petioles light green and red on upper side, light green beneath. Stipules green, leaflets very long and

narrow, Midribs of leaflets green on both surfaces. Petioles of young leaves hairy, young leaves green. Leaves near tips of branches at time of flowering trilobate.

PHILIPPINE No. 5. KAPO WHITE OR GREEN.

Tubers.—Corky layer greyish-brown, thin and not easily separated from the cortex which has a pink tinge, flesh white.

Stems.—Corky layer greyish white, cortex dark green, leaf bases remain green on stem till it is mature. Young stems green.

Leaves.—Petioles light green occasionally tinged red near top and base on upper surface, stipules green, leaflets dark green above and whitish green beneath, midribs of leaflets light green on both surfaces with occasionally a slight pink tinge on upper surface. Young leafstalks bare, leaflets tinged brown.

JAVA No. 6. AIPIN VALENCA.

Tubers.—Corky layer nut brown, rather rough, and it peels off in strips exposing the cortex, which is light purple in colour, flesh white.

Stems.—Upright and do not branch early, corky layer brown with silvery markings, cortex dark green, young stem olive green with purple blotches.

Leaves.—Petioles dark red, stipules purple at base both inside and out, leaflets broad, dark green above and light green beneath. Midribs of leaflets red on both surfaces. Young leaflets brownish green, young petioles green and bare.

JAVA No. 7. AIPIN MANGI.

(See Philippine No. 4)

JAVA No. 8. MANDIOCA BASIORAO.

Tubers.—Corky layer dark brown and can be readily separated from the cortex which is white. Flesh white.

Stems.—Corky layer brown underlying silvery grey. Cortex deep green. Young stems dark green.

Leaves.—Petioles light red on upper side and light red and green beneath, stipules purple on the inside at base, leaflets dark green above and light green beneath, midribs of leaflets tinged red above and green beneath. Young leaves green, tinged brown. Young leaf stalks hairy.

JAVA No. 9. MANDIOCA CRIOLINHA.

This variety is said to be poisonous.

Tubers.—Corky layer brown to deep brown, cortex white, flesh white.

Stems.—Corky layer dark brown with brownish grey markings, cortex dark green, young stems green with purple lines on ridges.

Leaves.—Petioles dark red, stipules dark purple at base both inside and out. Leaflets dark green above and lighter green beneath. Young leaves purple, young leafstalks bare.

Java No. 10. Mandioca Sao Pedro Preto.

See Philippine No. 2.

The varieties described above may be classified into the following groups according to their tuber characters:—

(1) Those with brown corky layer and light purple cortex.

(2) Those with brown corky layer and white cortex.

(3) Those with white corky layer and white or creamy white cortex.

(4) Those with white corky layer and cortex tinged pink.

Under (1) Aipin Mangi and Aipin Valenca may be placed. The difference between these two varieties lies in A. Mangi having young stems which are green while A. Valenca has purple blotches on the green stem. The petioles and midribs of the leaflets differ in colour as do also the size and shape of the leaflets. A. Mangi having light coloured petioles and green midribs to the leaflets which are very long and narrow, while the petioles of A. Valenca are dark red and the midribs of the leaflets are red on both surfaces.

Under (2) Mandioca Sao Pedro Preto, Mandioca Basiorao and Mandioca Criolinha may be placed. The first and last are very a like in habit of growth. They may be distinguished, however, by their stipules, which are red on the inside of the base only in the case of M.S.P. Preto, and on both inside and out in the case of M. Criolinha. The midribs of the leaflets are red on the upper surface only in M.S.P. Preto and on both surfaces in M. Criolinha. The young petioles, when less than 4 inches long, are hairy in M.S.P. Preto, while they are smooth in M. Criolinha. M. Basiorao differs from the other two in having young stems which are dark green and free from colour except at the leaf bases and petioles which are light red on the upper surface and light red and green beneath.

Under (3) may be placed Native No. 2, Native No. 3, Philippine No. 1 and Philippine No. 3. The last three differ

very little in stem and leaf character and it is difficult to tell them apart by these characters alone. Philippine No. 3 differs from the others in having long thin whip-like tubers. There appears to be no very apparent difference between Native No. 3 and Philippine No. 1. Native No. 2. however, differs in habit and general colouring of the stem. The green and reds being very much darker in No. 2 and the stem cortex is dark green, while it is light green in the others.

Under (4) come Native No. 1 and Philippine No. 5 (Kapo White or Green). These two differ, however, in general habit of growth and also in the general colouring of the plant. Native No. 1 having red colouring and the stem branches early whereas Kapo is green, it does not branch so freely and is taller.

I am indebted to Mr. S. Youngberg, Director of Agriculture, Philippine Islands and Dr. J. S. Cramer, of General Experiment Station, Department of Agriculture, Java, for help in clearing up some of the confusion which existed in the nomenclature of the varieties under trial here. Dr. Cramer has also helped by sending me pamphlets published by the General Agricultural Experiment Station on work done with the tapioca crop in Java. Most of these pamphlets were in Dutch and I am indebted to Mr. Rijk, Librarian, Agricultural Department, F.M.S. and S.S. for translation.

The pamphlets with five tables for the determination of 25 tapioca varieties by Dr. I. Boldingh, Scientific Assistant of the Sub-division, Seed Cultivation of Annual Crops, Buitenzorg, Java has been especially useful in verifying the names of the varieties described above.

The work of laying out and planting the above trials and also the collection of a large amount of the data was carried out by Mr. E. A. Curtler, Assistant Agriculturist, while he was in charge of the experimental work being carried out on this plantation.

Summary.

The sources of supply of planting material of the tapioca varieties grown at Serdang are given.

The literature from Java and the Philippine Islands has been reviewed and yield figures to compare with our own have been extracted and included in this report.

Yields of tapioca tubers obtained from each variety in various trials which have been carried out are given and the layout of the trials has been described.

Descriptions of the varieties grown on the Government Experimental Plantation, Serdang are given.

The Development of Methods of Obtaining Areas of Increased Productivity.

The following article is extracted from the India-Rubber Journal February 5th, 1927. The paper formed one of a series given at the third session of the International Rubber Conference, on 26th January, 1927, at Grand Palais, Paris.

In an exhaustive paper on this subject, Mr. J. Grantham, Director of Research to the United States Rubber Plantations at Kisaran, Sumatra, gave a survey of the methods which are being utilised on those plantations in Sumatra and Malaya for obtaining new areas of *Hevea brasiliensis* of higher yielding capacity than ordinary plantations.

The author inserted in his paper a table giving the classification of yield over a nine years period on a fairly uniform area of 12½ acres of rubber planted in 1911, the yield of every tree being collected each day and the dry yield being weighed half-monthly. The objects were to ascertain whether good yielders remained good yielders (a question which could be answered in the affimative for a great majority) and to ascertain the distribution of yield in a normal "population." The table showed that the yield of the two highest classes was over three times the average yield. The author added that this experiment had formed the basis of much of the scientific work done, and calculations from it had formed the basis of larger scale work.

Full particulars of many other investigations were given, and the writer expressed the opinion that the following systems were worthy of consideration for large scale planting of new areas, set down in order of merit:—

(1) Buddings of proved clones interplanted with seed from buddings;

(2) Buddings of proved clones only;

(3) Seedlings from seed of buddings planted densely enough to allow elimination of all poor yielders;

(4) Seedlings from seed of selected high yielders of the ordinary plantation planted in a similar manner.

It was not possible to see the end of the competition between buddings and seedlings, and it was quite probable that both would continue to be used for many years to come. Progress with a perennial tree crop must necessarily be slow, but it was under way, and the rubber plantations of the future would, the author believed, show results of scientific development comparable with those achieved in older agricultural industries.

Mr. Noel Bingley said he would like to mention a few further interesting features of bud-grafting results which he thought were worthy of attention.

(*a*) The yield per tapping of a budded Hevea, whether tapped at 20 inches from the ground or at two or three times that height, was the same. On his visit he saw instances of trees with two cuts at 40 and 80 inches from the ground respectively where the yield was the same, instead of there being the normal excess of 100 per cent. in favour of the lower cut on a non-budded tree.

For this reason it was advantageous to start the tapping on a bud-grafted tree much higher than in the case of a seedling, from the bark-conservation point of view as well as from that of yield. A further reason was that it has been proved that tapping too close to the juncture of graft with stock caused abnormalities in growth of the lower part of the stem.

(*b*) All the bud-grafted trees from a given clone would inherit any abnormality peculiar to the mother tree—corky bark, knobby stem, inclination to lean over, etc., generally in more pronounced form than was the case with the mother tree. He saw experimental areas planted with bud-grafts where the surface of all the trees was so covered with abnormal growths, and other areas where all the trees were leaning at such an acute angle that tapping was practically impossible.

(*c*) Some clones carried no seed.

(*d*) Buds from selected high-yielders would not "take" on stocks from any trees but their own mother tree.

(*e*) Experiments extending over many years had shown that of the buds from any hundred selected *elité* mother trees approximately only one third had better qualities than the parent tree, or the same qualities. One third of the number were doubtful and one third useless for propagation purposes. This result was confirmed by experiments carried out by the scientific officers of the A.V.R.O.S. in Sumatra, and consequently he was inclined to believe that in giving 8 as the approximate percentage of high yielders that transmitted their qualities to their offspring Mr. Taylor was considerably below the mark. *However, the most vital point, to his own mind, in the whole question was that until one had approved clones at one's disposal it was most inadvisable to attempt budding on more than an experimental scale, otherwise one ran the risk of establishing large areas in which approximately two-thirds of the trees were bad or doubtful yielders.*

For those who were anxious to institute this method of propagation without the delay of ascertaining by a slow and patient process of experiment which were really the reliable trees on their own estates to use for propagation, the only safe course was to purchase first-class budding material from other sources.

A point mentioned in Mr. Taylor's paper was selection of the best trees according to the number of rows of latex cells in the cortex, but he believed that this system had for some time been discarded, at any rate in Java and Sumatra, as not giving reliable results.

The Chairman, having thanked Mr. Bingley for reading summaries of the papers, said that the work in Ceylon had only just begun, and Mr. Taylor's paper was necessarily not much more than an account of what it was proposed to do there. Mr. Grantham's paper was, he thought, one of the most valuable of all the papers laid before the Conference, as it gave a very full account of what was actually being done. As Mr. Bingley had said, *many years must pass before the correct practice of bud-grafting could be part and parcel of ordinary plantation procedure, and any work along these lines must for the present be regarded as experimental.*

The sentences in italics are of importance in view of criticisms levelled against the opinion held by certain officers of the Department of Agriculture F.M.S. The Plant Physiologist (Mr. W. N. C. Belgrave) lecturing in Malacca in 1922, insisted that the work on bud-grafting must be regarded as experimental and judging from the above article, there seems little doubt this was the correct attitude to take up. In this lecture Mr. Belgrave said, "One point is certain, work must be undertaken in Malaya without delay. The only test is that of growth and tapping, a matter of six years at least—this sorting out of mother trees should be undertaken soon, so that should bud-grafting prove successful we may not be left behind".

Further, attention might be called to the paragraph referring to the unreliable results given by utilising the number of rows of latex vessels for the purpose of selecting high yielding trees. This point was made many years ago by this Department, but little notice was taken.

Recently, there has been a revival of extraordinary claims as regards future yield possibilities in rubber plantations. We do not doubt the possibilities of higher yields, but we maintain the position taken up several years ago i.e. that before bud-grafting can become a part of general routine many more years patient work is necessary.

It is most important that planters in this country should keep abreast of all developments of this nature and should, wherever possible, conduct properly organised experiments, but there is danger in popularising any scientific development which is still under investigation, in-so-far as the layman is inclined to regard optimistic statements as indicating an established position and to jump to the conclusion that methods still under investigation can be adopted as a general practice. The warning note comes, on this occasion, from keen supporters of bud-grafting, and this should be sufficient to indicate to interested parties that bud-grafting as a general practice should be adopted with caution and with a due regard to the best scientific directin.

A. S.

Publications of the Department of Agriculture.

The following publications, except those out of print, may be obtained on application to the Office of the Secretary for Agriculture; and the Malay States Information Agency, 88, Cannon Street, E.C. London.

A remittance to cover the cost should accompany applications; otherwise the Journals will be sent by post, Cash on Delivery, where that system is in force.

1. The Agricultural Bulletin F.M.S.

Vols. I—IV (1913-16) VIII & IX (1920-21) price $5.00 per volume.
Vol. V (1917) Nos. 1, 2, 3, 5 & 6 ,, 2.50 per set.
Vol. VII (1919) ,, 2—6 ,, 4.50 per set.

(Vol. VI is out of print.)

2. The Malayan Agricultural Journal (continuing the Agricultural Bulletin) Published monthly.

Vol. X (1922) Price $5.00 per volume.
Vol. XI (1923) Price $5.00 per volume or 50 cents per single number.
Vol. XII (1924) ,, ,, ,, ,, ,,

Back numbers of Vols. I.—X will not be sold singly.

3. The Handbook of Malayan Agriculture, price $1.00.

Current numbers of the Malayan Agricultural Journal and the Handbook may be purchased from the Railway Bookstalls and Branches of Messrs. The Federal Rubber Stamp Co

4. *Special Bulletins.*

1. Notes on *Termes Gestroi* and other species of Termites found on Rubber Estates in the Federated Malay States, by H. C. Pratt, 1909, 20 cts.
2. Root Disease of *Hevea Brasiliensis*, by W. J. Gallagher. C
3. Observations on *Termes Gestroi* as affecting the Para Rubber Tree and methods to be employed against its Ravages, by H. C. Pratt, 1910, 20 cts.
4. *Brachartona catoxantha, Hamps*, by H. C. Pratt, 1909. C
5. The Extermination of Rats in Rice Fields, by W. J. Gallagher, 1909. C
6. Branch and Stem Disease of *Hevea Brasilienisis*, by W. J. Gallagher, 1909. C
7. Coffea Robusta, by W. J. Gallagher, Government Mycologist, 1910, 20 cts.
8. The Cultivation and Care of the Para Rubber Tree (in Malay) 1910. C
9. Die-Back Fungus of Para Rubber and of Cacao, by K. Bancroft, 1911. C
10. A Lecture on the Para Rubber Tree, by W. J. Gallagher, 1910. C
11. Coconut Cultivation, by L. C. Brown, 1911. C
12. Padi Cultivation in Krian, by H. C. Pratt, 1911. C
13. A Root Disease of Para Rubber, *Fomes Semitostus*. by K. Bancroft. 1912, 20 cts.

C = Cancelled